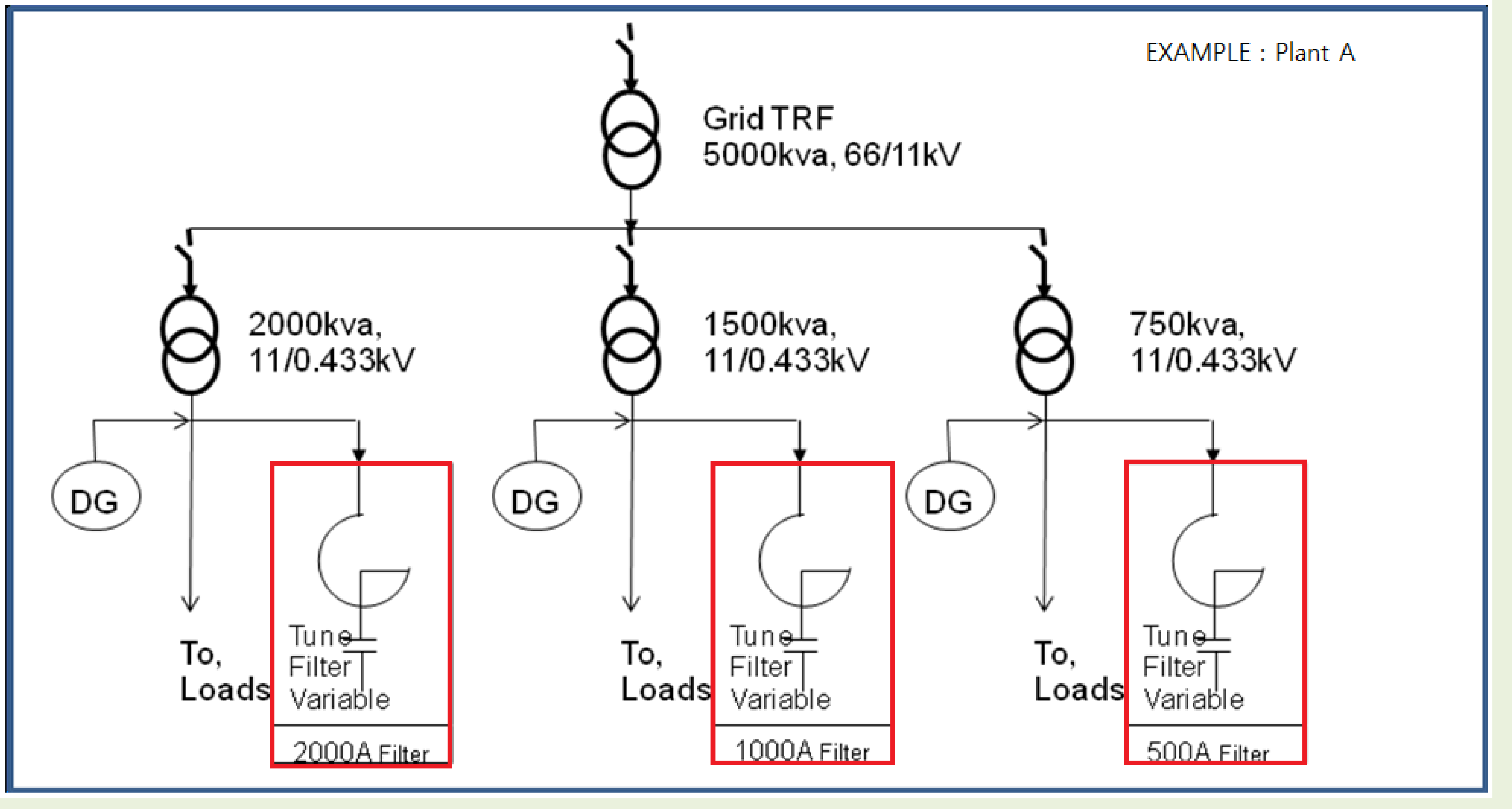
Document Nr: kti1605A

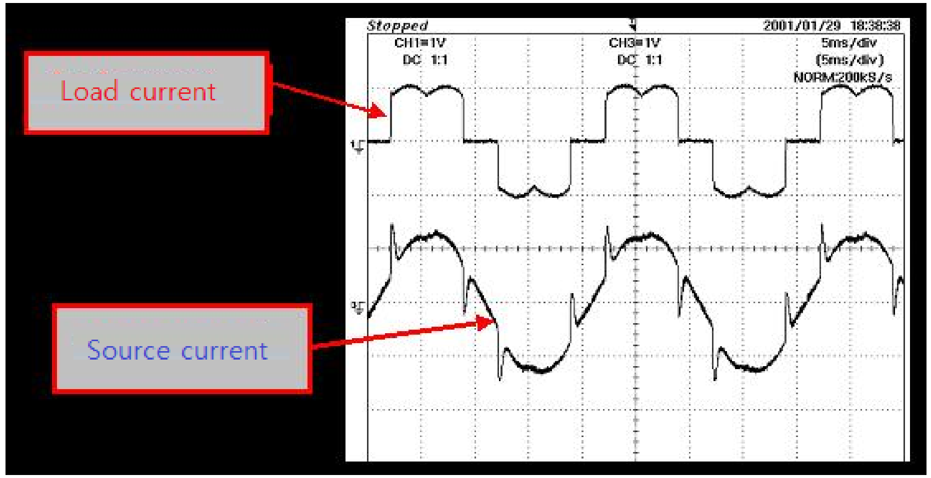
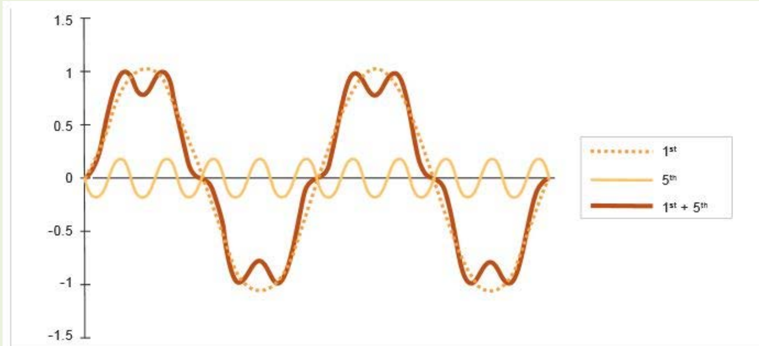
Question ware for the switching gear fault shooting sequence;

	Question ware	Answering
1	How many nuisance trip has been occurred during last 1 year or 3 months? -Switchgear trip repetition	Four times
2	How long switchgear has been used? ex : Life time	Since June 2009
3	What kind of treatments has been applied for repairing? -Switch gear changed, EMC treatment, Trimming adjust, PCB change in the M CCB or ELCB and etc	Only Auxiliary Contacts contactor and close/open in motor feeder and A Zener diode in the transformer feeder
4	Did you ever measured the power harmonics during long time?	No.
5	How about the temperature in the control room, controlled environment or not	Yes. Using control environment HVAC (heating, ventilating, and air conditioning).
6	Did you ever measured transient or surge on the main power line?	No.
7	Circuit in the MCCB, ELCB and Switchgear had epoxy molded or not? -To be checked after equipment open	Not applicable.
8	MOV, Zener, SCR are adapted in the switchgear pickup circuit? -Check on the circuit drawing	Zener diode in the Transformer feeders
9	Can I ask y whether the system software changeable or not?	Not. Our relay used ABB REF 542++
10	Are y kept the faulted switchgear?	It is transient and temporary fault and it is running know. we have the list of faulty feeders
11	Can y accept the switchgear model change as a normal mechanical switch with fuse if switchgear had an essential mortal weakness?	No.
12	Can y able to change the software sequence like a step 12 of following check list?	No. there are no facility to do this sequence.
13	Long term check on the dc voltage variation in MCCB, ELEB control board -Check on the low voltage than 3.3V??	Control voltage, supply from battery charger has no variation, can be conformed during your visit
14	1) Trip correlation with other system; - Condenser bank turn on/off - Other system turn on/off - Motor speed 2) Trip time and weather condition	
15	1)Tune filter for harmonic is installed or not? 2) Can you able to install the new tune filter if we recommended when filter is not installed ?	
	1) Low voltage than working level (including transient) 2) MOV heat failures by repeated surge or transient when epoxy molded condition	

Example: Tune filter installation against harmonics reduction;



1. Problem statement & type

	Statement & type
1	Nuisance Trip: Happens with moderate rise in THDv typically above 5%. Since THDv is omnipresent throughout power system it affects all power electronic drives –VFD /DC, PLC and associated Control System everywhere those are connected within the transformer supply. *Such trips are a wake-up call*. *Distorted waveform has plethora of **up/down spikes***. Drive's control & protection mechanism mistake them as fault condition. And initiate tripping once it exceeds threshold value. For example, it could trip annunciating over-voltage or over-current or under-voltage condition even though nothing like seem to have happened. Motors with digital control are more prone to nuisance trip than with analogue control. *Plant engineers do not easily find specific reason for such trip and on reset drive runs as normal*. In these plants nuisance trips were happening few times on every day or quarterly depend on the load condition. *This is because THDv was hovering much at a higher level between **10 to 15%.*** 
2	**Electronic Failure**: Happens when THDv rise considerable higher level typically above 7%. THDv being omnipresent affects all equipment those are connected within the transformer supply. Electronic–VFD/DC/Cards are first to fail being more susceptible to PQ followed by capacitor, fuse, motor ac/dc/servo/eddy-current, ct, pt, switchgear, transformer, cable and terminations. Rising THDv stress all equipment and reduce their life. In plant-A, alone one-electronic card used to fail on an average on every month.
3	Motor Failure SQIM, SRIM & DC: Happens when THDv rise much higher typically above 9%. THDv is omnipresent that affects all motor types within the transformer supply. These failures are often mistaken as overload burning. Plant-A, has SQIM between 5 to 30hp both constant speed and with VFD. Initial harmonic problems show-up in the forms of higher bearing temperature and/or phase current imbalance. Slowly it leads to stator winding failure either burn or open-up. Monthly about 10% SQIM used to fail. Plant-A, has SRIM between 50 to 150hp. Initial harmonic problems show-up in the forms of high bearing temperature and/or phase current imbalance. Slowly it leads to stator winding failure either burn or open-up. In-addition external rotor copper winding link, ring and also resistance (air-cooled) used to burn. On Occasions typically once in a year even sturdy rotor

	winding burn. Monthly about 3% SRIM used to fail. Plant-A, has DC Motor between 5 to 450hp. Initial harmonic problems show-up in the forms of field over current. Slowly it leads to field winding failure either burn or open-up. Commutator gets overheated. It leads to irregular gap between commutator segments as soldering bond between them give-up. Even with extreme care and monthly maintenance schedule there used to be occasional commutator burning. Occasionally and typically half-yearly even sturdy armature winding used to burn altogether in about 3 to 4 slots. Monthly about 5% DC Motors used to fail. Motor with analogue control found prone to field winding failure and motor with digital control to nuisance trip.
4	Capacitor failure: In these plants Harmonic Distortion (50% THDi & 15% THDv) was so high capacitors were even blasting and frequently. Usually capacitors keep failing without giving out much signal that keeps reducing kVAr output. Rarely capacitors blast. This necessitated frequent replacement of capacitors. These happened due to rise in both THDi and THDv. In-addition capacitors themselves contribute in magnifying both THDi & THDv to an extent that is determined by short-circuit impedance of the power system and connected capacitive impedance. As a rule of thumb more the capacitors installed more would be the rise in harmonic both THDv & THDi, further complicating PQ and harmonic distortion problem. Low PF systems are less efficient in utilization of electrical power. Historically simplest solution is to add capacitors to correct inductive load. However such approach creates serious operation problem if harmonics are present. Any combination of capacitance and inductance forms a circuit which get tuned to what is called as "RESONANCE FREQUENCY". It is the frequency at which both capacitive & inductive reactance equal. If significant harmonic energy is present and its frequency matches with that of resonant circuit formed by PF correcting capacitor and system inductance, it would excite current into an oscillation. A very large amount of harmonic current would flow magnifying harmonic voltage. Its effect could damage equipment & reflect in excessively high harmonic in the entire power system. In addition, since high oscillation current in the resonant circuit is wasted and no useful work is done it would drop PF. However capacitors do not themselves create any harmonic problem but their presence in circuit aggravate potential harmonic problem. Many times harmonic related problems show-up after capacitors are introduced.
5	Switchgear; MCCB/ACB, cable, termination & lug overheating & burning: Harmonic like current source flow from downstream-load wherein it gets generated to upstream as it offers least impedance path. Harmonic is high frequency current (or voltage) for example 5th harmonic is 250/300Hz current or voltage. On the other hand plant & machineries design for 50/60Hz operation. Thus all alone its flow path harmonic causes excessive heat generation, energy losses and ageing for switchgear, transformer, cable and terminations. In plant-A, cables that normally run at 10C above ambient used to run even 20C to 30C above ambient mostly at termination points wherein lugs & cable insulation used to burn out. It used to happen on an average once in 3-months. In-addition Capacitor with MCCB combination routinely used to fail blasting.

2. Engineering Objectives

2.1. To achieve highest **Profitability**.

The secret to highest profitability is simple reduce costs & increase earnings. Firstly, factories with PQ & harmonic solutions in place will operate near 80 to 100% LF. This considerably reduces initial "**Project Cost**" and thus continued financial holding cost. Better PQ enhance equipment life. Optimum LF ensures least energy consumption. Together they considerably reduce "**Running Cost**". Adhering to highest product quality reap premium sales realization. Minimizing reject & improving MTBF considerably enhance production volume.

2.2. To achieve highest **Energy Efficiency** & to promote **Green Energy**.

Bad PQ & harmonic distortion are less efficient in utilization of electrical energy; extent of loss depends on complexity of harmonic distortion. In-addition equipment de-rating cause further energy losses. On top of it lesser productivity creates higher energy losses. In totality in this ACSR plant on the basis of 6-months before & 6-months after scenario data, 9% energy saving achieved in kWh terms and 20% savings in kVAh terms.

2.3. To **Trouble-shoot** operational issues that are attributable to none among conventional causes and hence fall under the category of PQ & Harmonic issues.

In these plants even with history of such huge failures and issues this objective is fully achieved and almost instantly on installation of "Encon Ih Filter". It should be kept in mind that PQ & harmonic distortion create early ageing and on post-solution scenario there could till be some equipment closer or near failure-point aging level.

2.4. To achieve highest **Productivity**.

In these plants we closely monitored production data 6-months before & 6-months after scenario. It was observed productivity or for that matter production increased by 25% due to a) significant reduction in rejection rate and b) considerable improvement in Mean Time between Failure (MTBF).

2.5. To achieve highest **Quality**.

In these plants multi-strand aluminium conductor, 8-strands, 48-strands or so are manufactured up to predefined length in between 1.8 to 2.1kM. Somewhere in the middle few strands used to shear-out and way out was to solder them. But it always raises quality issue apart from lowering production and idling man-power. Post-solution scenario this issue almost eliminated. Another problem was rejection of entire length on higher lay-ratio that is slackness between strands of conductor that reduce its overall current carrying capacity. Its major cause is nuisance trip. There was about 1% such rejection. It reduced to its logical minimum of less than 0.5% on post-solution scenario.

2.6. To achieve & steadily maintain near **UNITY PF**.

Conductor manufacturing process employ highly variable load. In-addition about 60% loads is of Non Linear nature due to **which PF-capacitors** used to fail/degrade rapidly. Plant management was facing tough time maintaining proper PF and needed frequent capacitor replacement. In Post solution scenario and for 6-months wherein data was closely monitored on a daily as well as monthly basis, PF steadily maintained near UNITY level.

Tune Filter & effectiveness

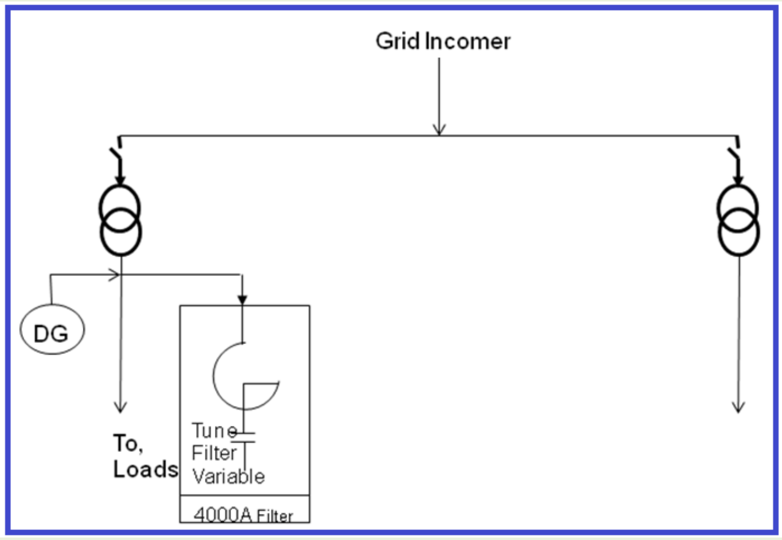


Figure 1 : Total Harmonic Distortion, THDv & THDi –before & after Tune Filter

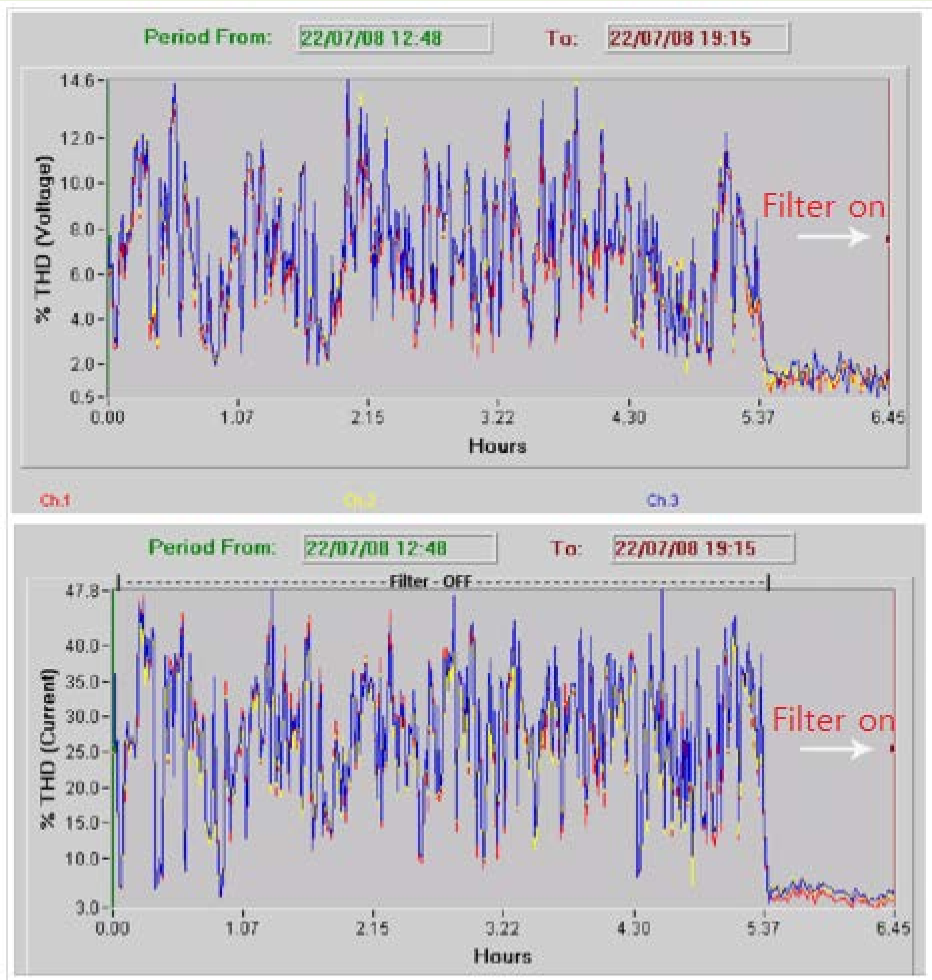


Figure 2: Total Harmonic Distortion, THDv & THDi –before & after Tune Filter

Figure 3: Individual Harmonic, VHAR & IHAR –before & after Turn Filter

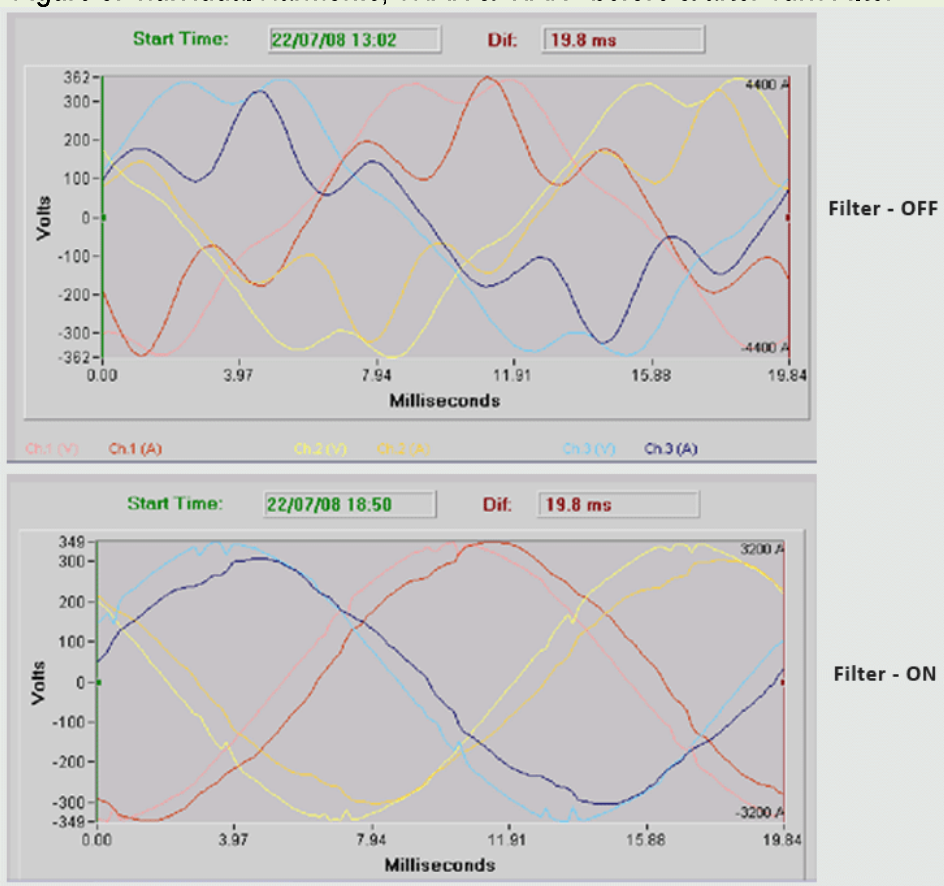


Figure 4: Individual Harmonic, VHAR & IHAR –before & after Tune Filter

Related standard;

NRS 048-2 VOLTAGE LIMITS

NRS 048-2 Regulation	Nominal Voltage (V)	Minimum Voltage (V)	Maximum Voltage (V)
6%	11000.00	10340.00	11660.00
6%	3300.00	3102.00	3498.00

IEEE STD 519-1992 CURRENT DISTORTION LIMITS

Maximum Harmonic Current Distortion (I_h) in percentage of I_L						
Individual Harmonic Order (Odd Harmonics)						
SCR	h <11	11≤h<17	17≤h<23	23≤h<35	35≤h	TDD
<20	4.0	2.0	1.5	0.6	0.3	5.0

IEEE STD 519-1992 VOLTAGE DISTORTION LIMITS

Bus Voltage at PCC	Individual Voltage Distortion (%) *(HD_V)*	Total Harmonic Voltage Distortion (%) *(THD_V)*
$\leq 69kV$	3.0	5.0